

SELECTED ENVIRONMENTAL CONCERNS FOR SMALL
HYDROELECTRIC DEVELOPMENT IN OREGON

by

Judy A. Kelly

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Dr. Keith W. Muckleston

ABSTRACT

Small hydroelectric development, the construction or reconstruction of small scale hydropower systems, has become a much discussed alternative for the future supply of U.S. energy. In the Pacific Northwest, the greatest potential for small hydro application is in the development of new dam sites. Although much is known about the environmental effects of large scale hydroelectric development, the environmental effects of smaller dam projects are less defined. The objective of this report is to review environmental considerations for small hydroelectric development applicable to Oregon.

Potential physical effects of small dam projects will likely include alterations of flow patterns, increased water temperatures downstream, and changes in streambank stability. Ecological relationships may be altered where fish runs are disturbed or special habitat is threatened. Recreational use of a river will be changed by the addition of a hydroelectric facility. A concern for historic or archaeological sites will need to be addressed in the planning stage of Oregon's small hydro development.

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SELECTED ENVIRONMENTAL CONCERNS FOR SMALL HYDROELECTRIC DEVELOPMENT IN OREGON

INTRODUCTION

Energy supply is now one of the most critical problems facing the American nation. Projected scarcities of fossil fuel, the ever-escalating price of oil, and continuing questions about nuclear power have initiated a new and serious appraisal of alternative energy sources. Explorations of solar, methane, geothermal and wind power are being conducted by both public and private research. In keeping with this emerging concern for new technologies, the Federal government has begun to investigate the potential for developing small hydroelectric sites. Termed small hydro or low-head, development of these smaller systems could help augment energy supply at critical times. Application of low-head technology at existing dams now without facilities for energy production would create a new energy source for less than full development cost. The possibility for low-head application is enormous in much of the country, and no area has such untapped potential as the Pacific Northwest.

In September of 1977, the University of Idaho Water Resources Research Institute entered into a contract with the U.S. Department of Energy (DOE) to conduct a study entitled "A Resource Survey of Low-Head Hydroelectric Potential--Pacific Northwest Region." The University of Idaho in turn subcontracted to the Institutes of Oregon, Washington, and Montana to do portions of the study involving streams in their respective states. Nearly concluded, this study directed attention at two major foci of low-head development. The first phase was an inventory of all rivers and streams in the region that contained sufficient

flow to produce a given power demand. This was done by the identification of a stream or river section with a capability of 36 cfs at least 50% of the time. This figure corresponds to the flow required to produce 200 kilowatts (KW) at 20 meters of head. For Oregon, this definition established an estimated 1443 reaches (river sections) where low-head development was hydrologically feasible.¹

In the second phase of the study, all existing dams in the Pacific Northwest were reviewed for the potential addition of power generation. If found to have sufficient head and flow characteristics, the site was listed and described in the final DOE report. This portion of the study identified 96 structures in Oregon which have either undeveloped or underdeveloped hydroelectric capacities.

Feasibility tables, both for defined reaches and for existing dams, are included in the final DOE report. These tables function as a checklist to identify constraining features of a potential site likely to inhibit development. The tables include information related to transmission and load considerations, as well as a brief review of local environmental conditions. The feasibility tables were designed as a quick overview of conditions, and in no way account for all pertinent environmental factors. (See Appendix A, Sample of Feasibility Table).

The extent of environmental impacts resulting from small hydro development is largely undefined. While much information has been generated with regard to the environmental effects of large dams, literature concerning small dam systems is either silent on the subject of the environment, or tacitly assumes the effects will be on a minor scale, concentrated mainly in the area of fish passage. While this

assumption might have been adequate for discussion of theoretical small hydro development, it is not sufficient at a time when the development of low-head technology is being seriously considered in many areas of the country.

The DOE workshop for small hydro in New Hampshire called attention to this vital gap in information and stated, "Generic assessments are important for establishing baseline information on a regional or river basin basis with respect to environmental parameters."² There is little environmental data available on functioning small hydro projects. No evidence exists which indicates that environmental effects from small hydro will be directly proportional to size. If there is one appreciation planners have gained through studies of the natural realm, it is a growing respect for the myriad of ecologic interdependencies that make up a biological system. Each human-caused perturbation in the ecosystem will initiate change within than complex system. While exact relationships between small dams and potential environmental changes are not known, it is possible to outline the areas where change should be expected, and to identify critical areas that will need further study.

The focus of this report is on the identification of potential environmental changes which may result from new dam development. While much attention has been given to the retrofitting aspect of small hydro development, there is relatively little potential for redevelopment of existing small dams in Oregon. Unlike conditions in the New England and Midwest states, there are few abandoned dams in the Northwest where redevelopment seems economically justified at this time. In Oregon, a far greater potential exists for new site development.

This report will consider the environmental impacts of small hydro

development on rivers and streams in Oregon. While many potential environmental changes can only be identified by field investigations, some potential problems may be identified on a regional level.

DESCRIPTION OF SMALL HYDRO POWER

The Industrial Age in America was first realized with the introduction of low-head hydraulic power. Utilized to operate thousands of small mills and factories, developed water energy often became the raison d'etre of many New England settlements. With the advent of electricity in the 1880's the flexibility of electrically powered water turbines became evident. Built in 1882, the nation's first hydroelectric plant was a low-head installation at Appleton, Wisconsin that produced 12.5 KW.³ While hydroelectric development rapidly increased, economies of scale for larger generation facilities made small hydroelectric facilities less attractive and many of these older and smaller plants were abandoned. In addition, potentials for generation at many dams constructed throughout this century went undeveloped.

While complications in development, marketing and procedural aspects of low-head exist, the rising cost of energy is creating a more favorable climate for small hydro reappraisal. Utilities are reconsidering small plants and are reevaluating potential sites which had been ruled out in the past. Several major turbine manufacturers are examining the possible low-head market. Similarly, the U.S. Department of Energy is actively involved in low-head inventories, workshops and studies that span wide areas of informational concerns. Low-head research funds are expected to reach \$330 million over the next two-year period, with most grants emanating from the Department of Energy. Given the extent of national attention, and the scope of current research, it seems apparent that small hydro systems will again be a force in American energy production.

The definition of a small hydro project has undergone considerable revision during the 15 months of the low-head study (Sept. 1977 - Dec. 1978). The current low-head range as cited by the Department of Energy involves any size dam with a maximum of 15 MW potential and no head limitations.⁴ Working under a more restricted definition, the Oregon study team and Pacific Northwest inventory project selected sites based on a maximum head. For purposes of that study, a low-head site was defined as power produced from sites with gross hydraulic heads from 3 to 20 meters (60 ft). It was assumed that any new low-head project would operate essentially as a run-of-river unit with no storage capacity. While the above description may not hold exactly for all future developments in small hydro, it does provide a working definition for potential low-head design.

The actual design and construction of a small hydro project will vary tremendously according to site geomorphology, flow characteristics and local hydrologic conditions. While it is impossible to describe the total extent of development effects of any kind of general level, it is possible to outline selected potential effects most likely to occur. The following section will attempt to integrate known environmental changes due to conventional hydro power production with characteristics of small hydro development. The resulting outline provides a framework for further environmental investigations at the project level.

The transformation of a lotic environment to an impounded reach may involve shifts in land utilization, water quality and biological habitats. Difficulties with attempts to organize these changes into logical divisions have led to a variety of methods and evaluation techniques. In general, this report will rely on a modified framework

developed by Battelle in its work for the U.S. Army Corps of Engineers.⁵ In some instances other methodologies and guidelines have been incorporated into the framework.

Four general levels of potential environmental effects of small hydro are discussed. Evaluation begins with the primary physical changes resulting from dam construction. Discussion continues through potential alterations of ecological relationships, human use patterns, and changes that would result in human response to an altered environment.

ENVIRONMENTAL CONCERNS FOR SMALL HYDRO DEVELOPMENT IN OREGON

Discussion

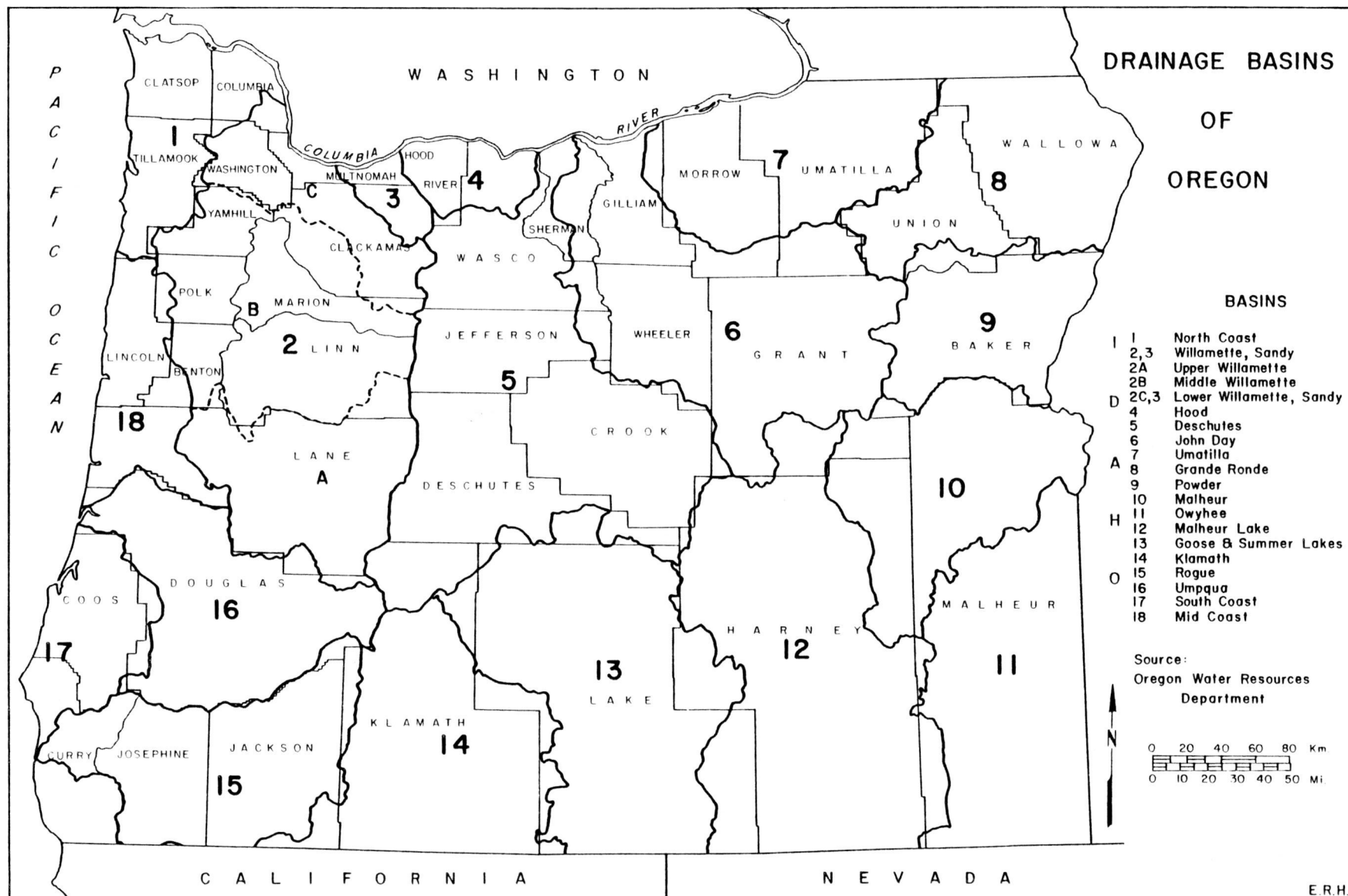
The first phase of the Pacific Northwest resource survey of low-head hydroelectric potential is now completed. Seven-thousand-six-hundred and twenty-six miles of Oregon rivers were surveyed and grouped into 1443 reaches where small hydro development is hydrologically feasible. As expected, streams influenced by the high precipitation rates of the Coastal and Cascade Ranges possess the greatest potential developable energy. Of the Pacific Northwest states, Oregon stands second in total power potential and contains about one-fourth of the region's total developable small hydro in-stream power and energy potential.⁶

As part of the Oregon survey an attempt was made to review possible impediments to small hydro development. Using existing information, the Oregon study team reviewed each defined reach for potential problems related to land use, structure and utility displacement, and special fish problems. The "land use" restrictions were based on established federal use and jurisdiction. Restricted lands included reaches along wild and scenic rivers, national recreation areas, national parks, national wilderness areas, known reserved natural areas, or areas with identified archaeological sites. It was found that 11% of the study reaches had some form of land use restraint.

From a review of maps, it was determined that the displacement of utilities and residential or commercial buildings would be a restraint for about one-third of the 1443 reaches. However, the lack of up-to-date information for many parts of the state, and continued development in these mapped areas, may have led to an underestimation of the

magnitude of this restraint. An attempt was also made to identify areas where problems with fish might alter the feasibility of small hydro development. Using maps and information provided by the Oregon Department of Fish and Wildlife (and predecessor agencies) the reaches were reviewed for problems that related to fish habitat, migration routes and spawning areas. Specifically, salmonid and sturgeon populations were considered to be the important fish resources in the state. Accordingly, little attention was given resident fish populations in the feasibility review. A total of 1023, or 71% of the Oregon reaches were identified as having potential fish related problems from small hydro development. These restraints were predominant for coastal streams, where 84% of reaches in the five coastal basins had special fish restraints, and for basins adjacent to the Columbia River (Figure 1).

The intention of the preliminary feasibility analysis provided by the Oregon study was not to establish the complete range of potential environmental problems. Instead, it was to illuminate some basic environmental conditions (e.g. anadromous fish, structure displacement) that could be expected to substantially alter the feasibility of small hydro development. Many other factors such as site geology, sociologic considerations, and established human use patterns were not taken into account by the feasibility analysis. While many of these omitted factors are site specific and require a detailed reconnaissance investigation of the individual project, it is possible to identify in a general way, a set of environmental problems that will require special attention in Oregon. This report will attempt to identify factors which may demand a greater amount of investigation from study teams working on small hydro in Oregon.



Oregon has established itself as a model for the nation in matters of environmental protection. Throughout a long history of legislative precedents, the state has fostered the tradition of insisting that action be taken to minimize or reverse environmental deterioration. The willingness of Oregonians to act on matters of environmental quality has been often demonstrated. The implications of this public attitude for small hydro development are twofold. First, from the outset of project design this concern for environmental quality must be addressed and incorporated into the planning process. Second, information related to potential changes in the environment resulting from a given project must be made widely available, and public input must be sought at the earliest stages of development. In Oregon, the prevailing public attitude is clear: capricious environmental alteration is unacceptable.

New Dam Sites

The predominance of hydroelectric energy production in Oregon is long established. With 35 hydroelectric plants already existing wholly or partially within the state, the combined power generation provides for 85% of the total state demand.⁷ While energy facilities at some existing dams are being expanded, dam construction for power needs has decreased significantly in the last decade, with base load energy becoming increasingly dependent on thermal generation. With many of the 'best' dam sites in the state already developed for power, and with many environmental objections to new dam construction, the future of conventional hydropower is limited in Oregon. Low-head hydro, the construction of small dams, opens up a much wider range of possible hydro applications. Of the 1443 reaches identified in the Oregon study, only 56 were found to pass the feasibility requirements for small hydro development.

Factors that eliminated most of the sites include: the disruption of identified salmonid habitat, displacement of over four structures, infringement upon existing federal land use, and identified archaeological sites. (See Appendix A) However, it should be noted that the scope of a given project, and on-site evaluation will often significantly change the 'feasibility' of a project. In the future, many small hydro sites in Oregon, in addition to the 56 noted above, may be recognized as economically and environmentally viable.

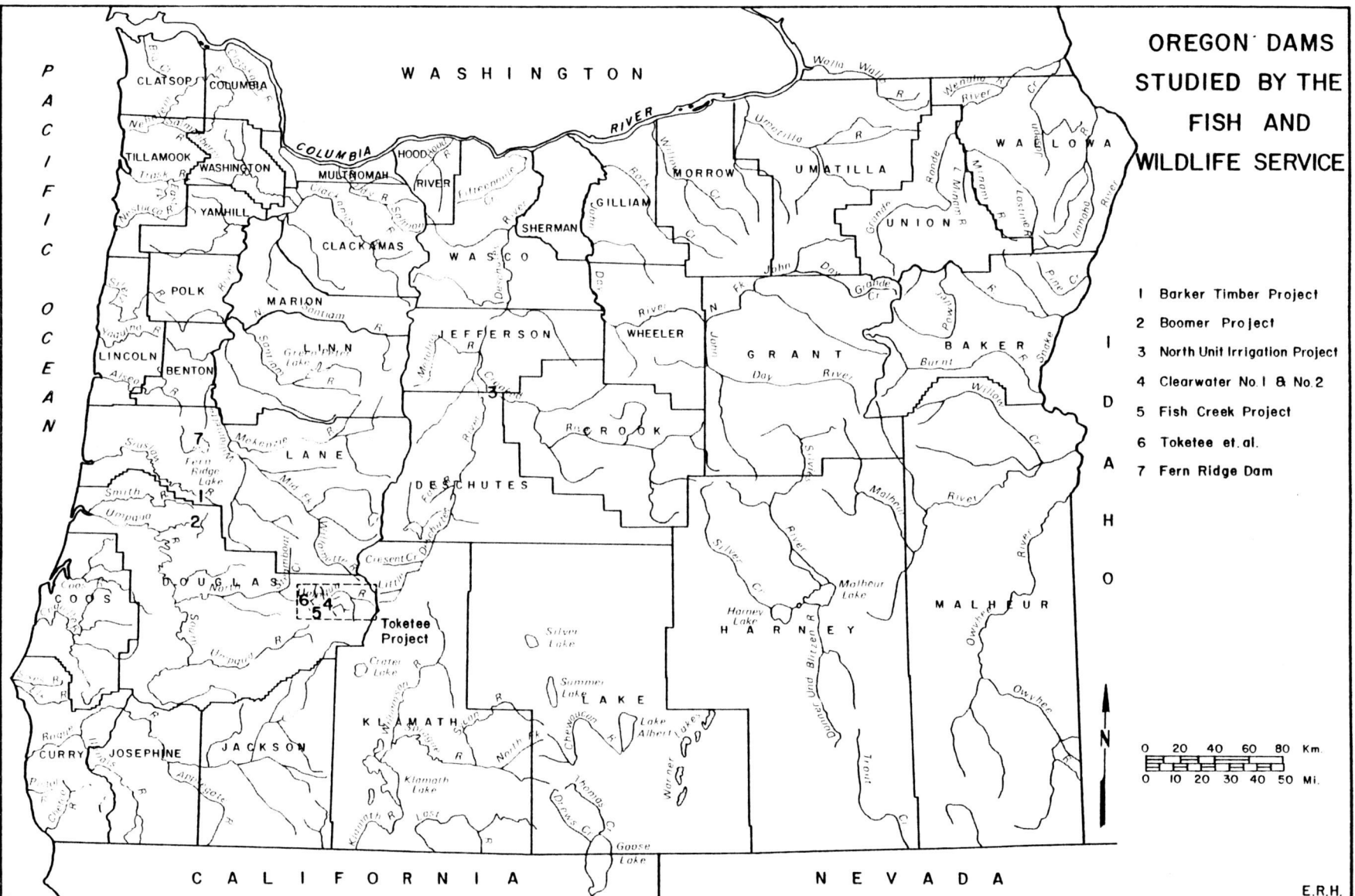
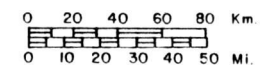
Similar to the situation on the national level, little empirical data is available on the ecological effects of small dams in the state. A noteworthy exception is a study prepared by the U.S. Fish and Wildlife Service which indicates certain biotic effects using pre and post-project studies.⁸ This report contains individual analyses of changed flow regimes below dams, the impact on fisheries, and methodologies used to assess flow requirements for 47 dams and diversions in the Pacific Northwest region. Of the 27 projects reviewed in the state of Oregon, 7 were found to be within the defined bounds of 'low-head' (i.e., were 60 ft. or less in height). Information taken from this report will appear under relevant topic headings (i.e., physical effects, etc.). A summary review of each project is available in Appendix B (Figure 2).

Level 1 - Physical Effects

The physical effects of a dam project include changes related both to land and water. Changes in the physical aspects of water include alterations of surface flow, disturbance of groundwater, alterations in water quality and changes in water temperature. Modification of the physical aspect of the land resource include changes in streambank stability, sedimentation rates, and in the nature and amount of riparian land.

OREGON DAMS STUDIED BY THE FISH AND WILDLIFE SERVICE

- 1 Barker Timber Project
- 2 Boomer Project
- 3 North Unit Irrigation Project
- 4 Clearwater No. 1 & No. 2
- 5 Fish Creek Project
- 6 Toketee et. al.
- 7 Fern Ridge Dam



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Water. Of the seven smaller projects reviewed for the Fish and Wildlife Service (FWS) in the state of Oregon, two projects were reported to have caused an increase in downstream temperature (See Barker & Fern Ridge in Appendix B). While these effects were rated 'minor' in the report, downstream temperature increases could be of great concern in areas where cold water fisheries exist, or in areas of already warmed water. The Oregon Department of Environmental Quality (DEQ) has identified streams within the state that may have an existing problem with elevated water temperature. In the DEQ report, "Oregon's Statewide Study of Non-Point Source Pollution," the agency has identified elevated water temperature as potential non-point source water problem.⁹ The study contains a general description of the areas affected by elevated temperatures, and provides a map which further identifies 'hot spots'. Information taken from the DEQ report, and the use of the non-point source maps should prove useful in a general review of small hydro potential. Establishment of a dam in these problem areas would require management practices that would not contribute to this condition.

Surface flow reductions were recorded at two of the projects reviewed by FWS (See Barker, Toketee et al., and Clearwater in Appendix B). The range of reported reduction in flows ranged from a 'slightly reduced summer flow' in the case of the Barker project, to an 81% reduction in average annual flow reported at the Clearwater project. As identified in the FWS report, the two water uses most affected by diminished flows were downstream consumption, and fish and aquatic habitats. In their non-point study, DEQ had identified areas that have existing water supply problems (e.g., areas where water withdrawals cause downstream quality problems). If a small hydro project might be

expected to significantly alter the available downstream supply of water, consideration of these special problems should be incorporated into project design.

In addition to those areas identified by DEQ as having 'low flow' problems, many of the streams in Oregon have established minimum flow requirements that must be maintained. The Water Policy Review Board is given statutory authority to establish minimum streamflows sufficient to support aquatic life and minimize pollution. While an established minimum flow is not an 'appropriative' right to water, it is (usually) treated similarly for purposes of water management and distribution. Minimum flows have already been set for many of the streams in Oregon, and hearings being held in the summer of 1979 will consider the adoption or amendment of minimum streamflows for 58 streams involving 12 of the state's 18 river basins.¹⁰ Compliance with such regulations might be of concern when assessing potential environmental impacts of small hydro projects.

Land. Information is also available from DEQ in regard to areas in Oregon that have existing streambank erosion and sedimentation problems. In the FSW report for Oregon, the Fern Ridge project was credited for reducing sedimentation and erosion on the Long Tom River. By stabilizing flow fluctuations, the process whereby banks are eroded was inhibited. (Fern Ridge does not produce hydroelectric energy at this time). Excessive erosion and sediment trapping could in turn affect the operation and longevity of a hydroelectric project. The potential for groundwater disturbance and the amount of land to be inundated by a project are directly dependent on the nature of the site. No such effects were mentioned in the FWS report.

Level 2 - Ecological Effects

Aquatic. The ecological effects of a small hydro project may range from changes in the pattern of drifting insects, to inundation of game habitat. In Oregon, however, the greatest concern with biotic resources will likely be with regard to modification of fish habitat. Of the dams reviewed by the Fish and Wildlife Service (FWS) this concern was reflected in the description of three of the small projects in Oregon (See Toketee et al., Fern Ridge, Fish Creek). At these sites, a variety of project effects on fish were recorded. At the Fern Ridge project, a stabilized flow regime and warmer temperature of the discharged water resulted in improved conditions for warm water fish, and the virtual elimination of cold water populations. At the Toketee project, an increase in reservoir fishery was recorded, along with a reduction in the stream fishery between the dams and the powerhouses (Figure 3). Fish Creek, on the other hand, reported no adverse effects on the fishery, and the installation of a fishway at the project site was termed an "apparent success." In general, the FWS report indicates that when minimum flow recommendations established by the Oregon State Game Commission were followed, the resulting impact on fish habitat was substantially mitigated.

At the outset of a project investigation, certain questions pertaining to the existing fishery resource should be answered. The type of fish either living in the stream, or dependent on the stream for part of its life cycle must be identified. Is the fish resident, migratory, game or non-game? Resident fish and non-game species are usually considered to be less important than migratory game species. It is the opinion of many wildlife biologists that more attention should be paid to these resident populations.¹¹ Important both in terms of

ecosystem diversity and as the source of much sport fishing, resident fish are often ignored by project planners. In the FWS report only minor adverse effects on resident fish were reported.

Spawning grounds are often damaged by construction. Direct loss of spawning grounds through inundation often results from the creation of an impoundment. On the Toketee project, 3.5 miles of 'marginal spawning grounds' were lost (Figure 3). This loss can be of special consideration where wild habitat is in short supply. The Oregon Fish and Wildlife Department has initiated a policy to retain wild fish habitat. While fish production loss can be partially ameliorated by the construction of a hatchery, the Department has become concerned about the diminishing amount of wild habitat and natural spawning grounds which in contrast to hatchery fish support the more vigorous and adaptable wild fish.¹² Spawning grounds may also be affected by dams in the downstream area of a river. Dams often trap bed load gravel being transported down the length of a stream. Acting as a barrier to downstream transport, the dam may stop gravel en route, and adversely affect the quality of downstream spawning grounds that will not receive the new material.

The dam as a detriment to migration may also be a consideration in small hydro design and implementation. Where fish ladders are deemed a necessity by investigating agencies, efficient design for small ladders is limited. The cost of a fish ladder on a small project can run up to \$3,500 a vertical foot. It has been stated that to provide a fish ladder on a small hydro project, the cost of such an addition may be up to one-third of the entire cost of the project.¹³ The need for a fish ladder on a small project can make the difference between

a cost effective endeavor and an inefficient use of development funds. Biologists working in the field must be very sure of the need for a ladder before they require a project to install one. Research is needed in the area of fish ladder design, it may be possible to standardize ladders for small projects, and thus reduce the cost. Small hydro is often viable on a rather slim margin of benefits, a \$30,000 fish ladder is frequently enough to alter the feasibility of development .

In Oregon, the most critical area for maintenance of fish habitat is along the Coastal streams. The Coastal region of the state contain the least disturbed portions of Oregon's anadromous fish populations. Many of the species once common throughout the inland waters of the Columbia network are now gone. Years of increased fishing pressure and most importantly, the loss of habitat and spawning grounds upstream from big dams has drastically reduced the Oregon fishery. Development of any size project in these Coastal areas should be initiated only after careful consideration of the alternatives to such an action, and the consequences in terms of a diminished resource.

Terrestrial. While fish are expected to be the prime environmental consideration in small hydro development, alterations of wildlife habitat will also be considered in project analysis. While no deleterious effects to wildlife were reported in the 7 study dams in the FWS report, different geographic conditions could increase the potential wildlife disturbance. Changes in the riparian habitat which ensue with the development of a small hydro system will require little attention in the humid areas of the state. Small in extent, these changes should be easily compensated by the existence of similar environments in close proximity. However, in the drier counties of the state, natural

riparian habitat may support a vastly disproportionate number of species. Arid regions of the state may well have stream ecosystems which provide for tremendous diversity in an area where lack of such an ecosystem would allow for the existence of fewer species. While most of Oregon's arid regions are not very attractive for small hydro development, the importance of the stream system should be viewed in a regional context.

As of January 1975, the Oregon Wildlife Commission identified 12 species of animals in Oregon considered to be threatened or endangered (See Appendix C). Of this groups of 12 animals, there are no indications that the development of small hydro would to any extent either affect their habitat, or alter their chances for survival.¹³ Project investigators should be aware of this list, but it is not expected to be a problem for small hydro production.

Level 3 - Human Use Effects

Dam construction may alter the established human uses of a river. Potential for water supply and recreational use of a river will be changed by the addition of a power generating facility. A short review of the major issues of river use in Oregon should provide background information to those interested in the possibilities for small hydro in Oregon.

Water Supply. Competition between hydropower production and water supply was not documented at any of the dams studied by the Fish and Wildlife Service (FWS). The FWS did note the existence of 'consumptive withdrawals' at Fern Ridge Reservoir but made no further comment on how those withdrawals might have affected other water users. In the humid areas of Oregon west of the Cascades, competition between small

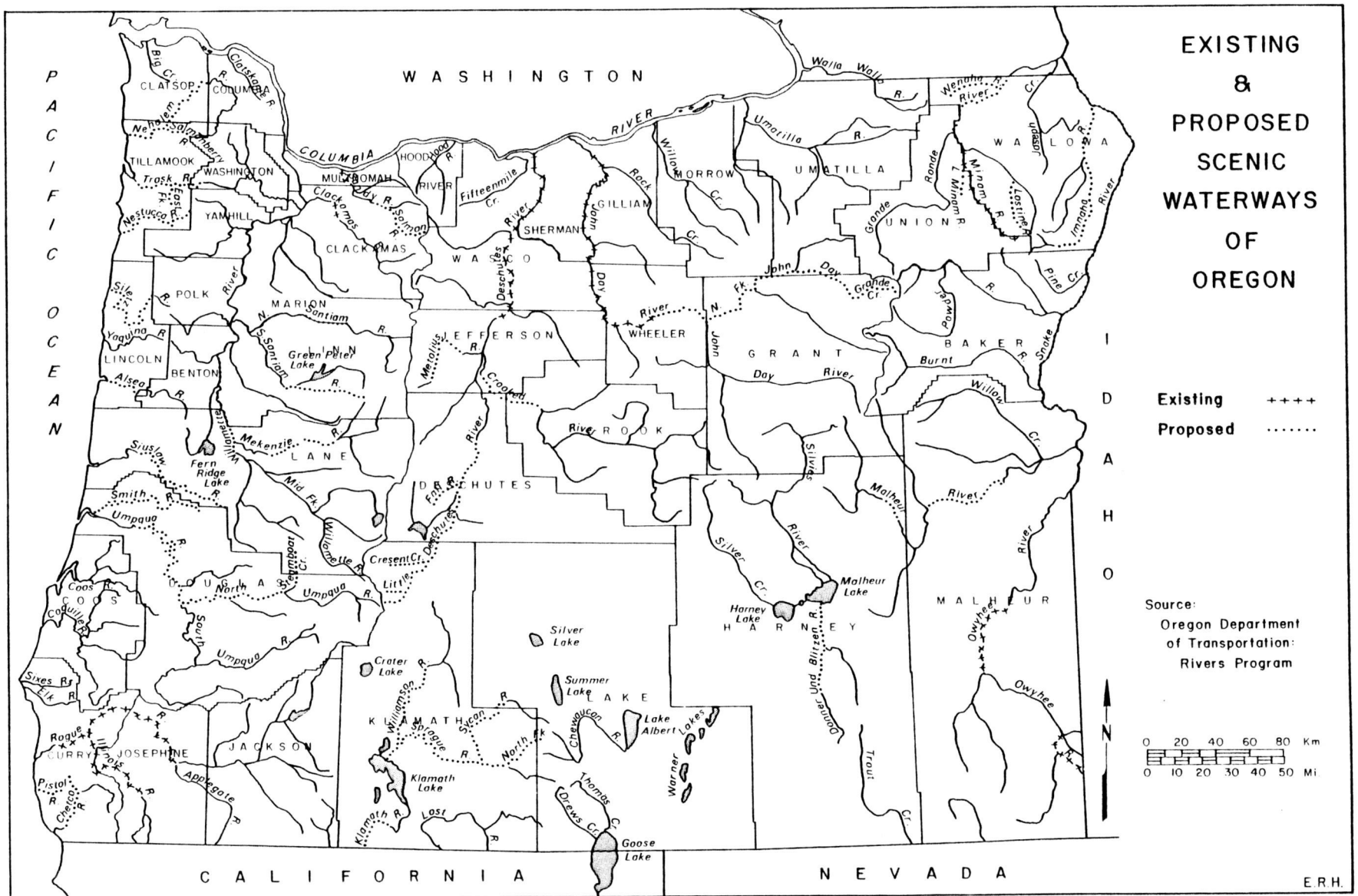
hydropower generation and direct human uses of water should not be of critical concern. If new dams and generation facilities are to be developed in the more arid regions of the state, established water use in the area would have to be carefully documented to assure a sufficient amount of water for existing uses, as well as the development of economically justified hydro sites. Much of this groundwork may be done by consulting the Oregon Water Resource Department, and by reviewing the existing appropriations for the river under study.

Recreation. The most severe conflict with small hydro development in terms of human use will most likely come from competition with recreational demand. Water recreation activity may be divided into three general categories. They include "whitewater" uses, such as rafting, and kayaking; passive water uses, such as fishing, and swimming; and slackwater uses, such as pleasure boating and water skiing. The building of a small hydro system along a given reach in Oregon will likely affect each of these uses.

The site requirements for "whitewater" recreation pose the most direct conflict with small hydro development. Dependent on swift water and unobstructed streams, whitewater sports cannot exist in areas of instream development. Several streams in Oregon are utilized by whitewash enthusiasts that include many reaches not protected in either the national or state wild and scenic river systems. Good swift water is characterized by a sufficient flow and a steep enough gradient to create turbulent sections of 'white' water. In this regard, the requirements for a whitewater run are similar to the requirements for a small hydro facility (i.e., flow plus head). It may be expected that many sites considered for potential hydro development will also be good

whitewater reaches. These two competing uses of a river resource are mutually exclusive and conflicts between such uses may be expected along many rivers in the state. Some of the most heavily used rivers in Oregon for whitewater activities include reaches which are designated as state scenic waterways (Figure 4). Development of small hydro facilities along these stretches will surely engender stiff opposition and public debate. To avoid the costly delays and complex litigation often associated with conflict of this sort, small hydro in these areas should be considered only after serious forethought has been given to the possible consequences.

Outdoor recreation in 'passive water' offers another set of possible conflicts with small hydro development. Activities that take place in quiet streams are not directly in conflict with power generation, but may be circumstantially inhibited by developments of this kind. In particular, salmon and steelhead anglers in the state would view with consternation the proposal to dam any reach that supported a run of anadromous fish. Hydroelectric dams on the Snake and Columbia Rivers have been cited as the cause for the reduction of approximately one-half the traditional spawning habitat for salmon and steelhead in the Columbia Basin. While this fishery has declined drastically in the last 40 years, the number of salmon and steelhead sport anglers has risen from 172,332 in 1960 to 394,419 in 1977 in a 128% increase.¹⁴ With the expected rise in the Pacific Northwest population over the next several decades and a continued increase in socioeconomic factors that account for increased per capita participation, the sport sector will continue to provide substantial new competition for the anadromous resources. It is unlikely that this sector of the recreating public will approve of small hydro



development in streams with established runs. Even where fish passage facilities have been constructed at existing dams, researchers estimate juvenile losses going downstream to be 8-20% and adult losses going upstream 15%.¹⁵ Hydro development in streams that support natural runs of anadromous fish will be hard to justify given the diminished quality of the resource.

In a few instances some slack water forms of recreation may be benefited by small hydro development. In regions where lakes and reservoirs are heavily utilized by the recreating public, and where increased access would allow for greater usage, small hydro might provide for a limited amount of slack water recreation. The significance of this increase would be limited however, by the rather small area of backwater behind a low-head dam. Reservoir fish would be increased in the impounded areas, and could attract an increased use from fishermen interested in resident populations. Given the small areal extent of a small hydro impoundment, pleasure boating should not be expected at most potential sites.

Human Response Effects

Effects of small hydro development on human response may be divided into three sets of potential change. These include changes related to socioeconomic factors, changes in cultural values, and changes in the aesthetics of a region. Socioeconomic changes are generally dependent on local conditions and further discussion with reference to regional predictions would be highly speculative. However, certain cultural and aesthetic resources may be related specifically to Oregon. Elimination of any of these special resources would diminish the quality of life for all Oregonians.

Archaeological. Certain to be of major concern to Oregon hydro development is the identification of archaeological sites within a developable area. While most historic sites (e.g., covered bridges, pioneer graveyards, old churches, etc.) are obvious during an initial reconnaissance for a proposed hydro site, indications of indigenous human occupation remain hidden and require detailed excavation. During the first phase of study for low-head feasibility, the Oregon study team contracted out to the University of Oregon to obtain information on identified archaeological sites. With a 'low-head' definition at that time of 'maximum head 60 feet', a total of 242 sites were found to exist close enough to the stream bed to be inundated by small hydro development (Table 1). The archaeological sites listed in Table 1 are only those that have been reported to the Oregon Archaeological Survey. Since very little archaeological research has been conducted along most of the waterways involved in the Oregon small hydro study, there are undoubtedly many more unrecorded sites within each drainage basin. Several archaeological surveys along major waterways have been conducted and provide some basis for projecting the number of sites to be found along Oregon's waterways.

An inventory of Bureau of Land Management lands along the Lower Deschutes River resulted in the recording of 187 sites, 135 of which are archaeological sites, the remaining being of historical interest. In another survey, 25 miles of Deschutes, Metolious and Crooked Rivers were reviewed in connection with the construction of Round Butte Dam. This review produced a total of 31 archaeological sites.¹⁶ It seems evident that identified sites are no more than a sample of the total number of sites existing within a basin. Accurate determination of these areas can only be accomplished by field investigations.

Table 1. Number of Identified Archaeological Sites in Oregon (by basin).

<u>Basin</u>	<u>#</u>	<u>Basin</u>	<u>#</u>
North Coast	16	Powder	5
Upper Willamette	31	Malheur	0
Mid-Willamette	3	Owyhee	Not Available
Lower Willamette	3	Malheur Lake	4
Sandy	1	Goose & Summer Lakes	9
Hood	1	Klamath	5
Deschutes	43	Rogue	7
John Day	55	Umpqua	30
Umatilla	4	South Coast	7
Grande Ronde	13	Mid-Coast	5

There appears to be a few identified historic sites in Oregon that would be affected by small hydro development. Few recognized sites are situated close enough (with 60 ft) to a river bed to be inundated by dam construction. Information about historic properties in Oregon may be obtained through the state preservation office, by consulting the National Register of Historic Places, or by contracting regional or county planning offices.

Aesthetics. Into all of us, there has been bred a love of rivers. Back to our beginnings goes this love, back to the Nile and Jordan, Tiber and Thames, to all the nameless rivulets that have watered life down the ages and generations, for 'a river went out of Eden'.¹⁷

Flowing water, through site and sound, gives distinction to our surroundings. Whether the environment is being used for work, for

recreation, or habitation there is an enrichment of place by its presence. Yet, how water contributes aesthetic value or adds to environmental quality is difficult to describe. The definition and identification of aesthetic environments must be framed with reference to temporal, locational and situational constraints.

It is evident that personal taste and experience become involved with an individual's aesthetic values. While a small hydro unit may appear innocuous to one viewer, the same structure may epitomize environmental degradation to another individual with a different set of values. Development of small scale hydro will clearly involve environmental tradeoffs. Although smaller in size than conventional hydro, small hydro installations will nevertheless alter the character of a stream.

Oregon has undoubtedly been endowed with some of the most scenic rivers and lakes in the country. While some of these rivers remain in a natural state and others have been developed for economic gain, most all still possess remarkable scenic, wildlife and recreational values. With the passage of the Oregon Scenic Rivers Initiative in 1971, the citizens of the state formally declared their concern for the special quality of many Oregon waters. Development of the water resources in the state requires attention to this public attitude and concern. The value of a stream in terms of aesthetic quality and the resulting enhancement of human experience should not go unexamined. Building a dam of any size requires a long term commitment of the stream resource. Before such decisions are made, planners should be fully cognizant of the implications of their actions.

SUMMARY AND CONCLUSIONS

In this brief review of potential environmental concerns about small hydro development in Oregon, several issues come to light. It seems apparent that existing hydrologic conditions favor the development of new sites for small hydro application within the state. The construction and maintenance of such sites will exert an influence upon the total stream system creating potential problems in many sectors of the environment. For Oregon, environmental problems and issues with small hydro may include aspects of all four levels of potential effects.

Physical effects of a dam project were reported at four of the seven sites reviewed in the FWS report. Of these effects, the most significant result was the altered flow pattern established after the operation of the Clearwater project. In addition, increased water temperature was identified at two of the projects. Information gathered by DEQ on streambank erosion, sedimentation, etc., should prove useful to planners in the initial stages of small hydro review. Statutory declarations of minimum flows will certainly be of concern to small hydro development within the state.

Of the possible ecological effects from small hydro to be of major concern in Oregon, the dominant concern is certain to be fish. Concern for preservation of wild spawning grounds, diversity in the species distribution, maintenance of gravel beds and access to upstream habitat will need to be expressed in the analysis of small hydro. In addition, special consideration might be required where habitat make project development detrimental to land species.

Opposition from some recreational interests will likely result from many attempts to develop small hydro in Oregon. Recreationalists who

depend on unregulated, natural settings for their activities will hardly be in favor of new dams.

Human use and perception of a natural area will be affected by a complex of influences, including policy decisions on the local, state or national level. Public demands will evolve as new ideas and technologies are introduced into a culture. In an era of increased recognition of these changes, planners and resource developers are expected to be aware of public use patterns and responses, and to incorporate these factors into project design.

It is not likely that individual small hydro development will drastically alter any physical, ecological, or human relationship existing with Oregon's waters. However, small hydro developments will most likely alter the site conditions, existing ecological webs, and/or established human use patterns of an area. Attention to specific questions raised in the preceding report, at the early stages of planning, should help avoid serious conflicts in small hydro development and help site such developments where they are best suited.

FOOTNOTES

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- 14 Petry, Glenn, Pacific Northwest Salmon and Steelhead Fishery Report Vol. 1, (Pacific Northwest Regional Commission, 1979).
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APPENDIXES

TABLE II
FEASIBILITY, TRANSMISSION AND LOAD RESTRAINTS

REACH IDENTIFICATION NUMBER	FEASIBILITY RESTRAINT				TRANSMISSION AND LOAD CONSIDERATIONS			
	LAND USE RESTRICTIONS	UTILITY DISPLACEMENT	BUILDING DISPLACEMENT	SPECIAL FISH PROBLEMS	DISTANCE TO NEAREST LINE Miles	LINE CAPACITY KVA	LOCAL MARKET	DISTANCE TO CITY >1000 Miles

FEASIBILITY RESTRAINTS

Four categories of feasibility restraints were considered: land use restrictions, utility displacement, building displacement, and special fish problems. Each of these could cause problems related to the development of a low-head hydro project in a particular reach.

Existing land use often restricts alternative development. Therefore, the feasibility restraints considered in this study that might be applicable to a given reach were partially based upon the identification of a particular land use. These constraints included wild and scenic rivers, national recreation areas, national parks, national wilderness areas, known reserved natural areas, or identified archaeological sites. Information on existing land uses was obtained from USGS maps. Information on identified archaeological sites was obtained from the University of Oregon's Department of Anthropology.

The displacement of existing utilities poses a potential problem if a hydro development would cause their relocation. Several types of utility displacement were considered, including major highways, railroads, power lines, telephone lines or gas and oil lines. Location of these items was based on USGS maps or other easily accessible mapping. A ground reconnaissance was not carried out for each reach.

The displacement, removal or relocation of existing residential and commercial buildings due to low-head hydro development represents another potential problem. The location of buildings in potential areas of inundation was determined by inspection of USGS quadrangle maps. Again, a ground reconnaissance was not carried out for each reach. In general, no constraint was identified unless more than four

residences or commercial buildings appeared to be in danger of inundation in any mile of the reach.

Aquatic ecosystems may be jeopardized by all types of stream development activities. However, it was determined not to deal in detail with the extensive and complex habitat relationships at this preliminary level of evaluation of hydropower potential. Instead, it was decided to focus on special problems related to fish passage, these being considered to represent the most significant feasibility restraint. In particular, a restraint was indicated if the reach supports a run of salmonids or if a sturgeon population that is an endangered species is present. Information was based upon the basin reports of the Oregon Department of Fish and Wildlife (and its predecessor agencies) and upon similar readily available documents.

An "X" marked in any of the columns representing feasibility restraints means that the particular feasibility category has been identified as posing problems for that reach.

APPENDIX B
OREGON STUDY DAMS

General Description

Name: Barker Timber Project

Location: 123°16'43"04' (Farman Cr.) Mid-coast Basin

Height: 20 ft, 186 acre feet rec. res.

Principal Use: Recreation.

Comments: Area of study; one mile downstream from dam until confluence with Siuslaw. Dam constructed in 1970. Conclusion made on very limited qualitative data.

Level 1 Effects

Caused a noticeable, but minor effect on downstream temperatures. 69°F upon entering impoundment, 72°F upon release. Slightly reduced summer flow caused by reservoir surface evaporation.

Level 2 Effects

Oregon State Game Commission (OSGS) recommended .5cfs year round flow.

Farman Creek is cold water fishery.

OSGS report implied dam would be detrimental to the production of migratory salmon and cutthroat trout.

Somewhat reduced summer flow. Rearing habitat preserved downstream.

Watershed cover of brush, conifer, hardwood.

No substantial change reported.

Level 3 Effects

Only use to change was addition of recreation.

Forestry and grazing major land uses prior to project.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: Booker Project

Location: 123°11'43"07" (Bennett Cr.) Umpqua Basin.

Height: 6 ft.

Principal Use: Irrigation diversion.

Comments: Dam construction in 1975. One mile downstream of dam until confluence with Elk Creek in study area.

Level 1 Effects

Project has not significantly changed Bennett Creek's downstream physical characteristics. Summer flows slightly increased. Biological conditions have remained the same, or improved slightly. Minimum flow of .1 cfs observed. Three-fourths mile wide shoestring valley. Flat gradient.

Level 2 Effects

Coldwater fishery--good cover and water conditions. Spawning and rearing grounds for coho salmon, steelhead, cutthroat trout and resident trout. Excellent cover for beavers and quail.

Level 3 Effects

Forestry and grazing major land use.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: Clearwater 1 and Clearwater 2 (Toketee Project)

Location: 122°17'43"04" Umpqua Basin.

Height: 17 ft and 18 ft.

Principal Use: Power generation.

Comments: Dam constructed in 1953. 5 cfs flow recommended by OSGC.

Level 1 Effects

Average stream width has been reduced to approximately 10 feet in many places along the system as a result of reduced project flows. Average annual flow directly below Clearwater No. 1 has been reduced 81%.

Deep pools throughout the length of the river have provided for continued existence of the trout fishery during low flow periods.

Level 2 Effects

Existing rainbow and brook trout populations. Operation of Clearwater No. 1 power plant requires diversion of certain levels of flow regardless of the magnitude of stream flow in the Clearwater River. Low flow periods in basin mark extensive violations of 5 cfs minimum. Fish size small, but were historically small according to OSGC. Furbearing animals, principally beaver, continue to utilize area.

Level 3 Effects

Minimal human use prior to project.

Accessibility to reach has improved with power company roads. Still light usage by anglers because of limited fishery.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: Fern Ridge Dam

Location: 123°18'44" 07' Mid-Willamette Basin.

Height: 46 ft, 110,000 acre ft res.

Principal Use: Flood control, irrigation, recreation.

Comments: Dam constructed in 1941. Gradient through reach of 4 ft/mi.

Level 1 Effects

Decreased flow fluctuations. Warmer water now released.
Decreased fluctuations have stabilized stream banks, decreased soil erosion.

Level 2 Effects

Aquatic organisms are abundant, including mollusks, annelids and aquatic insect forms. Development of white crappie post project. Water regulation now benefits fisheries. Flow regime and warmer temperature of discharged water have resulted in improved conditions for warm water fish and virtual elimination of populations of cold water fish.

Level 3 Effects

Land use primarily agricultural, some livestock.
Recreational activities include boating, hunting, swimming, picknicking, fishing.
Some consumptive withdrawals.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: Fish Creek

Location: 122°26'43"13', Umpqua Basin.

Height: 25 ft, 10 surface acres imp.

Principal Use: Power production.

Comments: Construction in 1952. 5 mile stretch from dam to Umpqua.

Level 1 Effects

Stream depth and width highly variable depending on magnitude of flow.

Level 2 Effects

Resident populations of rainbow and brown trout downstream. Marked reduction of the downstream aquatic habitat since operation of F.C. Division Dam. Principal cause believed to be scouring by 1955 and 1964 floods. Project flows have not apparently adversely affected the fishery. Fishway apparently successful. Forest includes one of the main stands of mature Douglas-fir in the nation; not affected. Black tailed deer and Roosevelt elk are game species found along reach.

Level 3 Effects

Timber production is main use.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: North Unit Irrigation Project

Location: 44°21'121°07', Deschutes Basin.

Height: "Small dam"

Principal Use: Supplement irrigation.

Comments: Dam constructed in 1969. 20 mile reach between dam and downstream Chinook Reservoir in study area.

Level 1 Effects

OSGS recommended 10 cfs below dam.

Operation has not significantly changed the stream's physical characteristics. Run-of-river operation, pumping only occasionally to augment irrigation.

Level 2 Effects

No significant effect on downstream habitat.

Terrestrial habitat in canyon consists of native shrubs and trees clinging to deposits of alluvial soils.

Although furbearers and game species were evident along the affected stream reach, Oregon Department of Fish and Wildlife biologist indicated "no significant effect" on these animals resulted from dam construction.

Level 3 Effects

Little human use except for occasional fishing. Rainbow trout predominant sport fish.

Level 4 Effects

None reported.

OREGON STUDY DAMS

General Description

Name: Toketee, Slide Creek, Soda Springs Diversion Dams.

Location: 122°22'43"15", Umpqua Basin.

Height: 58, 45, (855 acre ft).

Principal Use: Power.

Comments: Dams constructed in 1951 and 1953. Lack of adequate gauging stations.

Level 1 Effects

Water depth has been reduced markedly between the Toketee, Slide Creek, and Soda Springs Diversion Dams and their respective power plants.

Level 2 Effects

Water fowl, furbearing animals, beaver and river otter, thrive in the varied streamside habitat throughout the length of the reach. Anadromous fish continue to migrate as far up as Soda Springs Diversion Dam. Rainbow, brook, cutthroat trout, steelhead and spring chinook no longer migrate as far upstream as Toketee Falls; terminated at Soda Springs Diversion Dam. Soda Springs Diversion Dam has rendered 3.5 miles of marginal spawning ground unusable. Fishery between each diversion dam has been negatively affected. The operation of Toketee and Soda Springs Dams has greatly increased the fish resources in their respective reservoirs, but stream fisheries between dams and power houses have slightly deteriorated.

Level 3 Effects

Logging principal land activity in higher elevations.

Level 4 Effects

25 cfs minimum flow recommended by CSGC (between each diversion dam and its power house) was to preserve the aesthetic appeal of 80 ft cascade at Toketee Falls.

APPENDIX C

THREATENED OR ENDANGERED OREGON WILDLIFE

<u>Mammals</u>	<u>Status</u>
Sea otter (<u>Enhydra lutris</u>)	T
Wolverine (<u>Gulo gulo</u>)	T
Kit fox (<u>Vulpes macrotis nevadensis</u>)	T
Columbian white-tailed deer (<u>Odocoileus virgianus leucurus</u>)	E
 <u>Amphibians and Reptiles</u>	
Western spotted frog (<u>Rana pretiosa</u>)	T
 <u>Birds</u>	
California brown pelican (<u>Pelecanus occidentalis californicus</u>)	E
Aleutian Canada goose (<u>Branta canadensis leucopareia</u>)	E
American peregrine falcon (<u>Falco peregrinus anatum</u>)	E
Arctic peregrine falcon (<u>Falco peregrinus tundrius</u>)	E
Northern bald eagle (<u>Haliaeetus leucocephalus alascanus</u>)	T
Northern spotted owl (<u>Strix occidentalis caurina</u>)	T
Western snowy plover (<u>Charadrius alexandrinus nivosus</u>)	T

T - Threatened
E - Endangered